Citation:

Fiorito LM, Marini M, Francis LA, Smiciklas-Wright H, Birch LL. Beverage intake of girls at age five predicts adiposity and weight status in childhood and adolescence. *Am J Clin Nutr.* 2009; 90 (4): 935-942.

PubMed ID: 19692492

Study Design:

Prospective Cohort Study

Class:

B - Click here for explanation of classification scheme.

Research Design and Implementation Rating:

POSITIVE: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

The objective of the study was to assess whether beverage intake at age five predicted adiposity from age five to 15 years.

Inclusion Criteria:

- Participants were part of a longitudinal study of the health and development of young girls living in central Pennsylvania
- Five-year-old girls' had to be living with both biological parents.

Exclusion Criteria:

- Absence of severe food allergies or chronic medical problems affecting food intake
- Absence of dietary restrictions involving animal products.

Description of Study Protocol:

Recruitment

- Families were recruited by using flyers and newspaper advertisements
- Families with age-eligible female children within a five-county radius received mailings and follow-up phone calls.

Design

- Participants and families were reassessed every two years (at ages seven, nine, 11, 13 and 15 years)
- Only girls with complete dietary intake and body weight data at four of six times of measurement were included in this study, which resulted in a final sample of 166 girls.

Dietary Intake/Dietary Assessment Methodology

- Three 24-hour recall interviews were conducted at each occasion by trained staff of the Dietary Assessment Center at the Pennsylvania State University by using the computer-assisted Nutrition Data System for Research (NDS-R) software (Database Version 4.01_30; Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN)
- At ages five, seven, nine, 11, 13 and 15 years, the participants provided three 24-hour recalls within a two- to three-week period, including two randomly selected weekdays and one weekend day
- Recalls were conducted from June through October
- At ages five, seven and nine years, mothers in the presence of their daughters were the primary reporters of the

girls' intake. At ages 11, 13 and 15 years, the girls were the primary reporters with mothers participating in the interview as needed. Participants were mailed a poster depicting two-dimensional representations of food portions (2D Food Portion Visual; Nutrition Counseling Enterprises, Framingham, MA) as a visual aid for estimating the amounts of food eaten. Nutrient data were averaged across three days to obtain an estimate of 24-hour energy

- Beverage data were averaged across three days to obtain an estimate of the number of servings reported consumed by using the 2005 Dietary Guidelines for Americans and the US Department of Agriculture (USDA) Food Guide Pyramid Guidelines
- Beverage data were grouped into three intake categories: Milk, fruit juice and sweetened beverage. Milk included whole and reduced fat (plain or flavored) milk and was quantified as that consumed as a beverage. Fruit juice was defined as containing 100% fruit juice.
- At age five years, artificially sweetened beverages were a small fraction of the girls' beverage consumption, so sugar and artificially sweetened beverages were summed into a composite variable referred to as "sweetened beverages." Sweetened beverages included the following:
    - Any sugar-sweetened or artificially sweetened fruit-flavored drinks, sports (natural or artificial) drinks, and drinks that contained <100% fruit juice
    - Sodas that included carbonated sugar-sweetened or artificially sweetened, caffeinated or decaffeinated colas
    - Sugar-sweetened or artificially sweetened, caffeinated or decaffeinated tea or coffee.
- The girls' intake of water was not assessed. Consumption in each category was expressed in servings (one serving=8 ounces).

Blinding Used

Not applicable.

Intervention

Not applicable.

Statistical Analysis

- Data were analyzed by using the SAS software package (version 9.1; SAS Institute, Cary NC). Descriptive information was generated for all variables of interest and each outcome variable was assessed for normality. In all analyses, P-values <0.05 were considered statistically significant. Change was defined as the linear decrease or increase in the variable of interest from age five to 15 years
- To examine the participants' change in adiposity and weight status, a mixed modeling approach (PROC MIXED; SAS Institute) was used. Spearman rank-order correlations were used to assess stability for milk, fruit juice, and sweetened beverages between measurement occasions from age five to 15 years. Stability is defined as the consistency of participants' beverage intake between two measurement occasions, which is represented by the correlation coefficient between values taken at two times across individuals. A series of simple regression analyses were conducted to determine whether the girls' intake of milk, fruit juice, and sweetened beverage at age five years was an independent predictor of their adiposity measured as percentage body fat at each time point from age five to 15 years. The contribution of each predictor variable was determined by examining the standardized variable estimate. Multiple regression analysis was used to determine whether sweetened beverage intake at age five years predicted the percentage body fat over time, after controlling for potential covariates. Covariates examined in the model included sweetened beverage intake measured at the same point in time as adiposity, 24-hour energy intake at age five years, parental education, family income and maternal BMI at study entry
- At age five years, girls were classified as drinking less than one, at least one and less than two or at least two servings per day of sweetened beverages. Differences in the percentage body fat, waist circumference, and BMI-for-age percentiles at each time of measurement among beverage groups were assessed by using repeated measures with a mixed modeling approach (PROC MIXED). Repeated-measures-type analyses (PROC GENMOD; SAS Institute), which are appropriate when dealing with binary data, were used to assess the following:
    1. Whether girls who consumed at least two servings of sweetened beverage at age five years were more likely to be overweight (≥85th BMI-for-age percentile) compared with girls with lower intakes
    2. Whether the proportion of participants who were overweight increased from age five to 15 years. PROC MIXED was used to examine the longitudinal changes in sweetened beverage and 24-hour energy intake, percentage body fat, waist circumference and BMI-for-age percentiles, assessed from age five to 15 years

for participants drinking less than one serving per day, at least one to less than two servings per day, and at least two servings per day sweetened beverages. Post hoc pairwise comparisons of sweetened beverage group membership were made by using the least squares means and by applying a Tukey adjustment for comparisons. Given that sweetened beverage groups were defined at age five years, we examined change for sweetened beverage intake only among groups from age seven to 15 years, excluding those who were five years of age. The main effect of beverage group and age and the interaction between beverage group and age were variables of interest.

Data Collection Summary:

Timing of Measurements

Unclear. Dietary measures were taken between June and October.

Dependent Variables

- Percentage body fat at each time point from age five to 15 years (sum of skin fold thickness, DEXA, BMI for age, waist circumference)
- Variable 2: Brief description (how measured?).

Independent Variables

Girls at age five were classified as drinking sweetened beverages per day (servings):

- Less than one
- At least one and less than two
- At least two.

Control Variables

- Sweetened five year old girls were classified as drinking less than one, one and less than two or two servings per day of sweetened beverages
- Beverage intake measured at the same point in time as adiposity, 24-hour energy intake at age five years, parental education, family income and maternal BMI at study entry.

Description of Actual Data Sample:

- *Initial N:* 197 (100% female)
- *Attrition (final N):* 167
- *Age:* Girls were five years old at the start of the study
- *Ethnicity:* Families were predominantly non-Hispanic and white
- *Other relevant demographics:*
  - The average income for the sample ranged from $50,000 to $75,000
  - Parents were relatively well educated: fathers had a mean (±SD) educational level of 14.9±2.7 years, and mothers had an educational level of 14.8±2.3 years
  - Parents were on average slightly overweight at the first time of measurement with a mean (±SD) BMI (in kg/m^2) of 28.0±4.35 for fathers and 26.4±6.05 for mothers.
- *Anthropometrics:*

Table 1. Mean Percentage Body Fat, Waist Circumference, BMI-for-age Percentile, and Proportion of Girls Classified as Overweight from Age Five to 15 years[1]

	Age 5 Years	Age 7 Years	Age 9 Years	Age 11 Years	Age 13 Years	Age 15 Years	Change (P-Value)
Body fat (percent)	20.6±4.32	21.8±5.6	26.8±7.5	27.3±7.1	26.9±6.8	27.9±6.0	<0.01

Waist circumference (cm)	—*3*	66.9±8.5	73.4±10.7	73.4±10.7	78.7±10.7	78.8±10.1	<0.01
BMI-for-age percentile*4*	59.3±26.6	58.2±27.7	64.0±26.9	63.5±27.5	62.4±26.1	61.3±24.9	<0.05
Percentage of sample overweight*5*	18	19	29	29	25	20.5	<0.05

1 N=170 for each age group. Mixed modeling analyses were used to generate the data in this table.

2 Mean±SD (all such values)

3 Data not available

4 Mean BMI percentiles correspond directly to the sample mean BMI by using age- and sex-specific Centers for Disease Control and Prevention growth charts.

5 Overweight is defined as ≥85th BMI-for-age percentile

- *Location:* Pennsylvania State University.

Summary of Results:

- Weight status, measured as BMI-for-age percentile, showed high stability between adjacent ages from age five to 15 years. The prevalence of overweight in our sample across the study period is similar to that shown by national data for the prevalence of overweight (≥85th percentile) in children and adolescents
- The association of sweetened beverages with milk (r= -0.20, P<0.01) and fruit juice (r= -0.19, P<0.05) intake was negative, whereas milk and fruit juice were not associated (r= -0.10, NS).

Table 2. Stability of Beverage Intake: Spearman Correlations Between Measurement Occasions of Beverage Intake in Girls Aged Five to 15 years[1]

Beverages	Age 5 to 7 Years	Age 7 to 9 Years	Age 9 to 11 years	Age 11 to 13 Years	Age 13 to 15 Years	Age 5 to 15 Years
Milk	0.62*2*	0.57*2*	0.45*2*	0.44*2*	0.47*2*	0.36*2*
Fruit juice	0.45*2*	0.24*3*	0.23*3*	0.25*3*	0.21*3*	0.14
Sweetened beverage	0.50*2*	0.56*2*	0.52*2*	0.42*2*	0.36*2*	0.23*3*

1 N=170. Column headings represent correlations between two ages (e.g., age five years correlated with age seven years).

2 P<0.0001

3 P<0.01

- Only sweetened beverage intake at age five years was a significant predictor of adiposity at each age from five to 15 years. Sweetened beverage intake at age five years significantly explained 9%, 7%, 9%, 5%, 3%, and 3% of the variation in the prediction of participants' percentage body fat at each time point assessed at ages five, seven, nine, 11, 13 and 15 years, respectively
- The association between sweetened beverage intake at age five years and adiposity from age five to 15 years remained unchanged after controlling for potential covariates
- Parents of girls in the beverage group drinking at least two daily servings of sweetened beverage reported lower income at study entry compared with parents of girls drinking less than one serving of sweetened beverage at five years (P<0.05). In addition, parents of girls in the beverage groups drinking at least one and less than two or at least two servings of sweetened beverages at age five years reported significantly lower education levels compared with parents of girls drinking less than one serving of a sweetened beverage at age five years

(P<0.001). No significant differences were seen among beverage groups for daughters' birth weight and maternal breast feeding. At study entry, theBMI for mothers of girls in the beverage group drinking at least two daily servings of a sweetened beverage was significantly higher than for mothers of girls drinking less than one serving of a sweetened beverage at age five years (P<0.05). Fathers of girls drinking at least two servings of a sweetened beverage had a BMI significantly higher at study entry than fathers of girls consuming less than one or at least one and less than two servings of a sweetened beverage at age five years (P<0.05).

Table 3. Standardized Regression Coefficients for Beverage Intake at Age Five Years in Predicting Percentage Body Fat in Girls Aged Five to 15 years[1]

Beverage Consumption at Age 5 Years	Age 5 Years (N=160)	Age 7 years (N=169)	Age 9 Years (N=158)	Age 11 Years (N=164)	Age 13 Years (N=150)	Age 15 Years (N=160)
Milk, unadjusted	-0.06	-0.02	-0.06	0.01	0.04	-0.08
Fruit juice, unadjusted	0.09	0.02	0.02	0.03	0.00	-0.02
Sweetened beverage, unadjusted	0.31*2*	0.27*2*	0.32*2*	0.23*3*	0.20*4*	0.18*4*
Sweetened beverage, adjusted for sweetened beverage intake at the age adiposity was measured		0.29*3*	0.30*3*	0.20*4*	0.21*4*	0.17*4*
Sweetened beverage, adjusted for energy intake at age five years	0.29*3*	0.26*3*	0.29*3*	0.20*4*	0.20*4*	0.18*4*
Sweetened beverage, adjusted for maternal BMI at study entry*5*	0.27*3*	0.22*3*	0.25*3*	0.15*4*	0.12	0.09
Sweetened beverage, adjusted for parental education at study entry*5*	0.30*3*	0.23*3*	0.24*3*	0.16*4*	0.12	0.08
Sweetened beverage, adjusted for family income at study entry	0.32*2*	0.28*3*	0.30*3*	0.23*3*	0.21*4*	0.18*4*

1 Standardized variable estimates made by using independent linear regression analysis

2 P<0.0001

3 P<0.01

4 P<0.05

5 Significant predictor of percentage body fat only at ages 13 and 15 years (P<0.05)

- The interaction of beverage group and age was significant only for percentage body fat (P<0.01). Although all groups showed increases in percentage body fat from age five to 15 years, smaller increases were noted for participants consuming at least two servings of sweetened beverage at age five years because of their significantly higher percentage body fat at age five years. The initial differences between beverage groups in percentage body fat persist to age 15 years, which indicates that girls drinking at least two servings of a sweetened beverage at age five years had higher scores for percentage body fat from age five to 15 years compared with girls with lower sweetened beverage intakes.

- Girls drinking at least two servings of sweetened beverage at age five years had higher BMI-for-age percentiles from age five to 15 years, higher scores for waist circumference and were more likely to be overweight from aged seven to 15 years compared with girls with lower sweetened beverage intakes.

Table 4. Percentage Body Fat, Waist Circumference, BMI-for-age Percentile and Percentage of Girls Aged Five to 15 years Classified as Being Overweight for Those Who Consumed Less than One, At Least One and Less Than Two, or At Least Two Servings Per Day of a Sweetened Beverage at Age Five Years[1]

Variable	Frequency of Intake[2]	Age 5 Years	Age 7 Years	Age 9 Years	Age 11 Years	Age 13 Years	Age 15 Years	P-value		
								Group	Age	Group x Age
	Servings per day									
Body fat (percent)	Less than one	20.2±3.6[3]	21.4±5.2	25.4±6.4	26.9±6.9	26.4±6.6	27.4±5.5			
	At least one and less than two	19.8±3.6	20.6±4.5	26.8±8.0	26.9±7.6	26.6±7.1	28.1±6.6	<0.01	<0.01	<0.01
	At least two	23.9±6.4	25.7±7.4	31.4±8.1	30.9±5.5	29.1±6.7	29.4±6.0			
Waist circumference (cm)	Less than one	__[4]	58.8±5.8	65.5±7.7	71.5±9.7	77.0±9.8	77.8±9.3			
	At least one and less than two	__[4]	58.3±5.3	66.4±8.3	74.1±11.6	79.0±11.1	79.1±10.6	<0.05	<0.01	NS
	At least two	__[4]	63.2±7.9	72.5±9.9	78.7±10.6	83.7±11.8	81.6±11.9			
BMI-for-age percentile	Less than one	57.6±25.5	56.2±27.3	60.8±27.3	60.1±27.0	60.1±26.2	60.3±25.5			
	At least one and less than two	56.6±26.6	56.3±26.7	63.0±26.8	63.6±29.4	62.4±25.3	60.4±23.9	<0.05	NS	NS
	At least two	70.5±28.9	69.4±29.4	77.1±22.4	75.4±22.5	70.6±26.9	66.6±25.2			
Overweight (percent)[5]	Less than one	16.1	15.1	24.2	21.7	22.2	18.5			
	At least one and less than two	11.8	11.8	29.4	29.4	19.6	18.4	<0.01	NS	NS
	At least two	38.5	46.2	46.2	53.9	46.2	32.0			

1 Mixed modeling analyses of variance were used to generate the data in this table

2 Frequency of sweetened beverage intake defined at five years: Less than one (N=93), at least one and less than two (N=51), at least two (N=26)

3 Mean±SD (all such values)

4 Data not available

5 Overweight is defined as at least 85th BMI-for-age percentile.

Author Conclusion:

Early intake of sweetened beverages predicts adiposity and weight status across childhood and adolescence.

Reviewer Comments:

The author's noted the following limitations:

- *Inability to generalize results beyond non-Hispanic white girls*
- *Relatively small sample size may have limited power to detect effects, for example, the failure to note differences in 24-hour energy intake across sweetened beverage groups*
- *Data were self-reported; thus, there is the potential for reporting bias. In fact, previous investigators have contended that foods that are high in added sugars, such as sodas, are selectively underreported*
- *Given the observational nature of this study, they cannot infer that the observed associations are causal; however, the data implicate early sweetened beverage intake in the development and persistence of obesity. The pattern of effects noted for the covariates used in this study suggests that sweetened beverage intake may be a marker of other lifestyle differences that affect adiposity.*

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions		
1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies)	N/A
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice?	Yes
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	N/A

Validity Questions		
1.	**Was the research question clearly stated?**	Yes
1.1.	Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified?	Yes
1.2.	Was (were) the outcome(s) [dependent variable(s)] clearly indicated?	Yes
1.3.	Were the target population and setting specified?	Yes
2.	**Was the selection of study subjects/patients free from bias?**	Yes

2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	Yes
2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes
2.4.	Were the subjects/patients a representative sample of the relevant population?	No
3.	**Were study groups comparable?**	Yes
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	N/A
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	Yes
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	Yes
3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	Yes
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	**Was method of handling withdrawals described?**	N/A
4.1.	Were follow-up methods described and the same for all groups?	Yes
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	Yes
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	Yes
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	**Was blinding used to prevent introduction of bias?**	Yes
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	N/A
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	Yes
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	Yes
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A

6.	**Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?**	N/A
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	Yes
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	Yes
6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	Yes
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	N/A
6.6.	Were extra or unplanned treatments described?	Yes
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	Yes
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	**Were outcomes clearly defined and the measurements valid and reliable?**	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	Yes
7.7.	Were the measurements conducted consistently across groups?	Yes
8.	**Was the statistical analysis appropriate for the study design and type of outcome indicators?**	Yes
8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes
8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	No
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	Yes
8.6.	Was clinical significance as well as statistical significance reported?	Yes
8.7.	If negative findings, was a power calculation reported to address type 2 error?	No
9.	**Are conclusions supported by results with biases and limitations taken into consideration?**	Yes
9.1.	Is there a discussion of findings?	Yes

	9.2.	Are biases and study limitations identified and discussed?	Yes
10.	**Is bias due to study's funding or sponsorship unlikely?**		Yes
	10.1.	Were sources of funding and investigators' affiliations described?	Yes
	10.2.	Was the study free from apparent conflict of interest?	Yes